# Experiment 4 Preliminary Work
# Impedance Measurement and Complex Power

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## Contents



## 1 Step 1

In this step the circuits given in Figure 1 is taken as the reference.

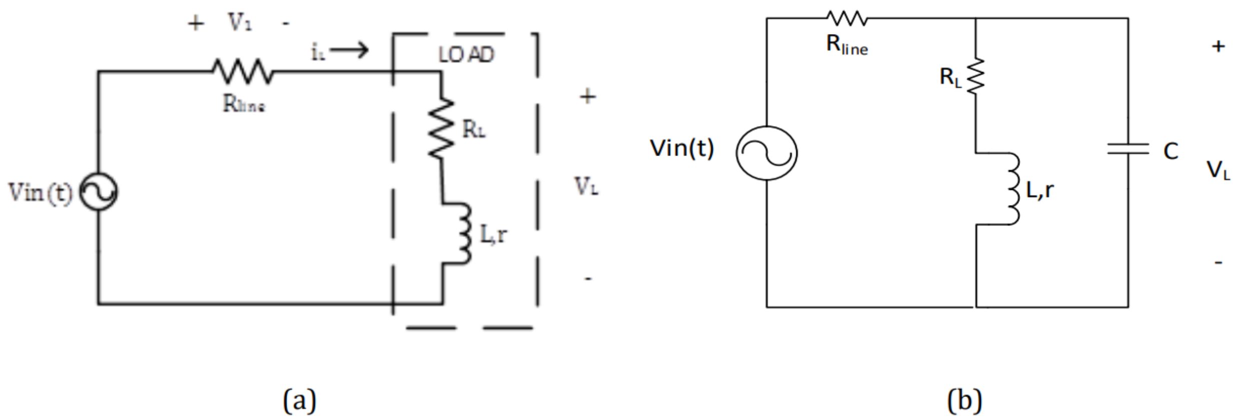


Figure 1: Circuit schematic for the step 1

## 1.1 a)

The circuit given in Figure 2 is constructed in LTSpice environment.

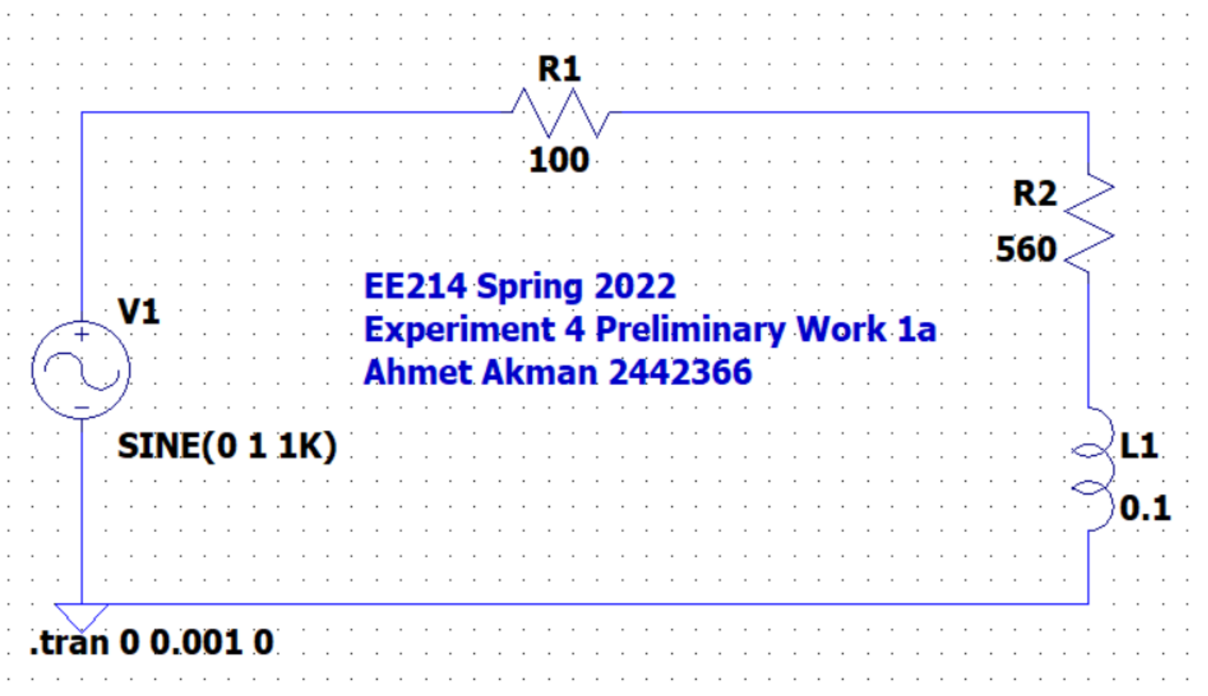


Figure 2: Circuit schematic in LTSpice for the step 1 part a

As a result the plot of voltage and current characteristics of input and load are given in Figure 3.

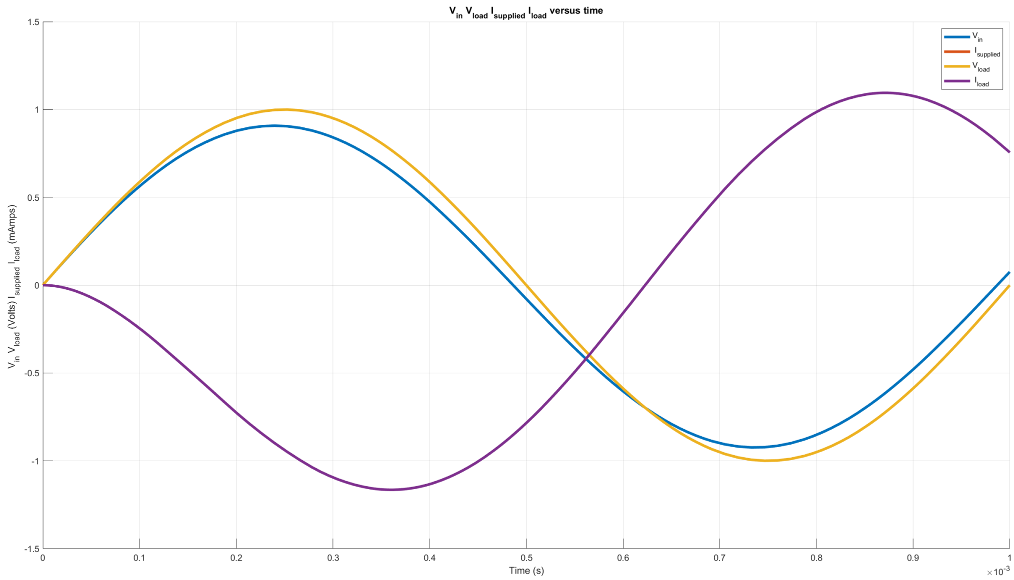


Figure 3: I and V versus time for Input and Load

To obtain power consumed at load, $IR2$ and $V_{load}$ are multiplied. The plot given in Figure 4 is obtained.

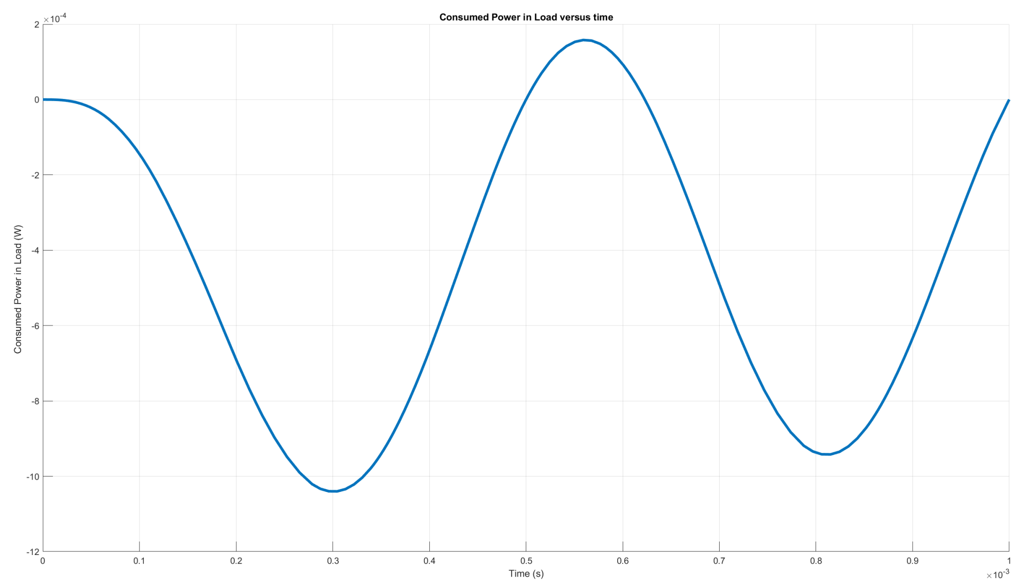


Figure 4: Power consumed at load versus Time

The average and the RMS values of the load power are calculated and given in Table 1.

Table 1: Resistance reading by color code convention.

| Average (W) | RMS (W) |
|---|---|
| $-3.61x10^{-4}$ | $5.37x10^{-4}$ |

## 1.2 b)

The circuit given in Figure 5 is constructed in LTSpice environment. In addition to previous step a capacitor with 100nF is connected.

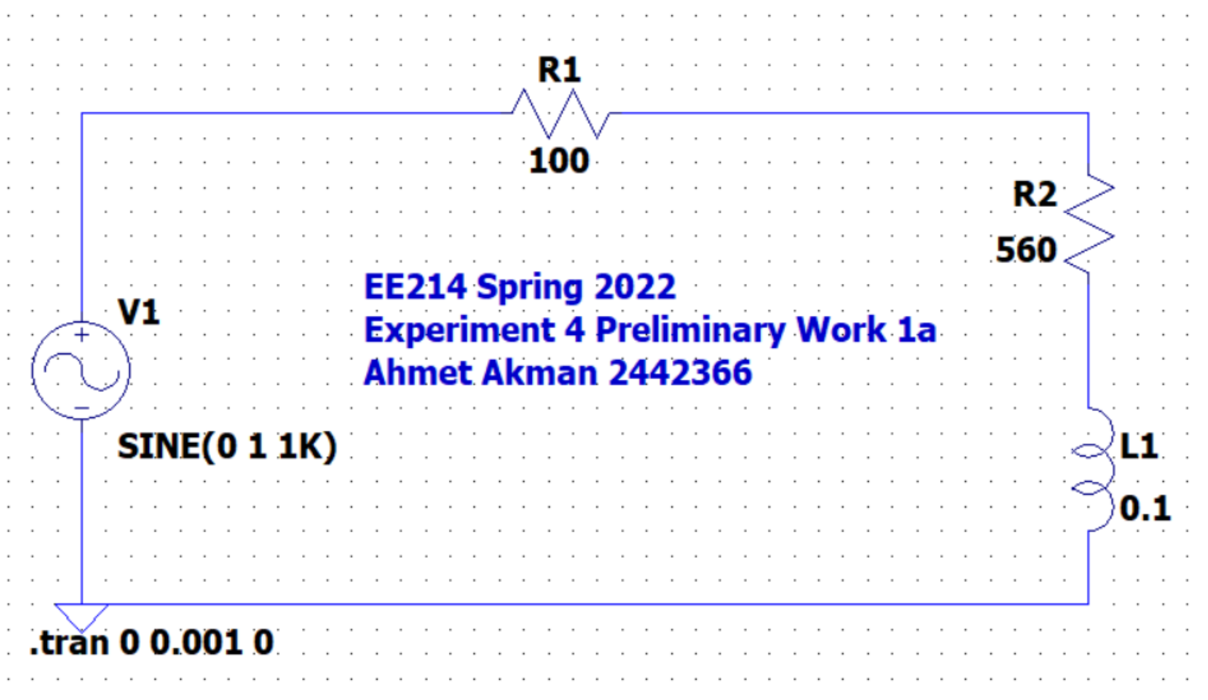


Figure 5: Circuit schematic in LTSpice for the step 1 part b

As a result the plot of voltage and current characteristics of input and load are given in Figure 6.

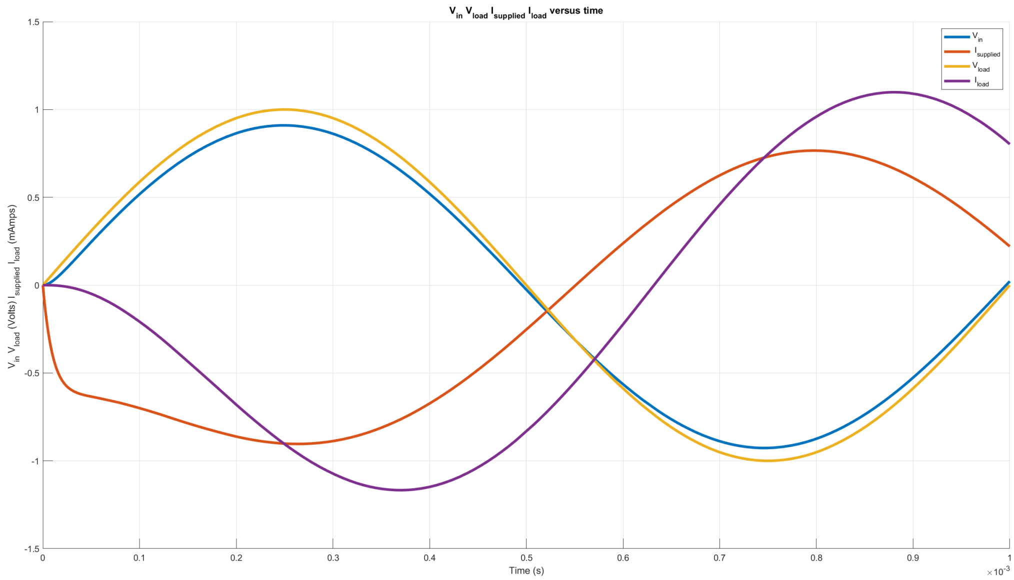


Figure 6: I and V versus time for Input and Load

To obtain power consumed at load, $IR2$ and $V_{load}$ are multiplied. The plot given in Figure 7 is obtained.

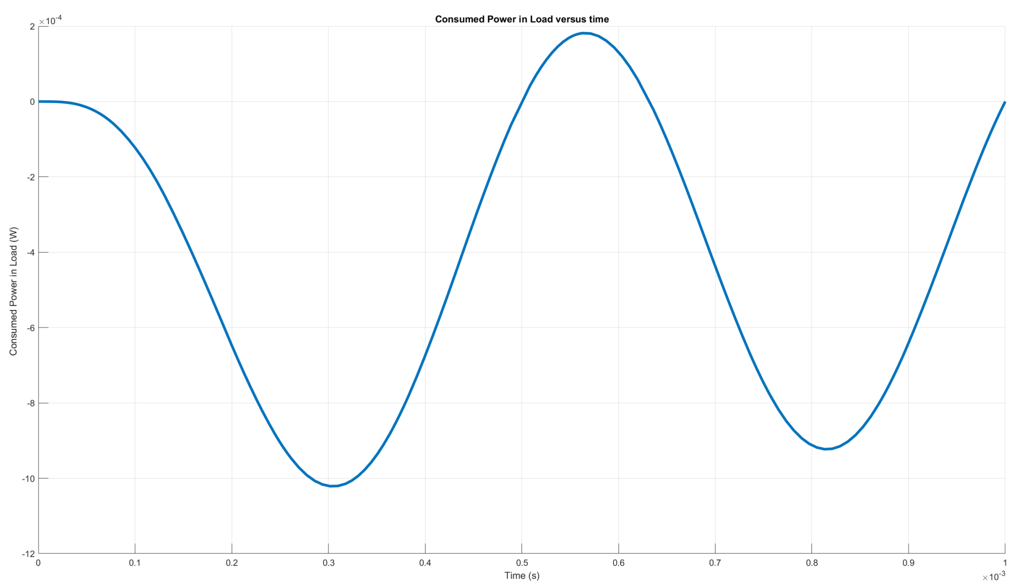


Figure 7: Power consumed at load versus Time

The average and the RMS values of the load power are calculated and given in Table 2.

Table 2: Resistance reading by color code convention.

| Average (W) | RMS (W) |
|---|---|
| $-3.4x10^{-4}$ | $5.16x10^{-4}$ |

# 2 Step 2

To determine a method to measure the unknown capacitance value C, the circuit given in Figure 8 needed to be constructed.

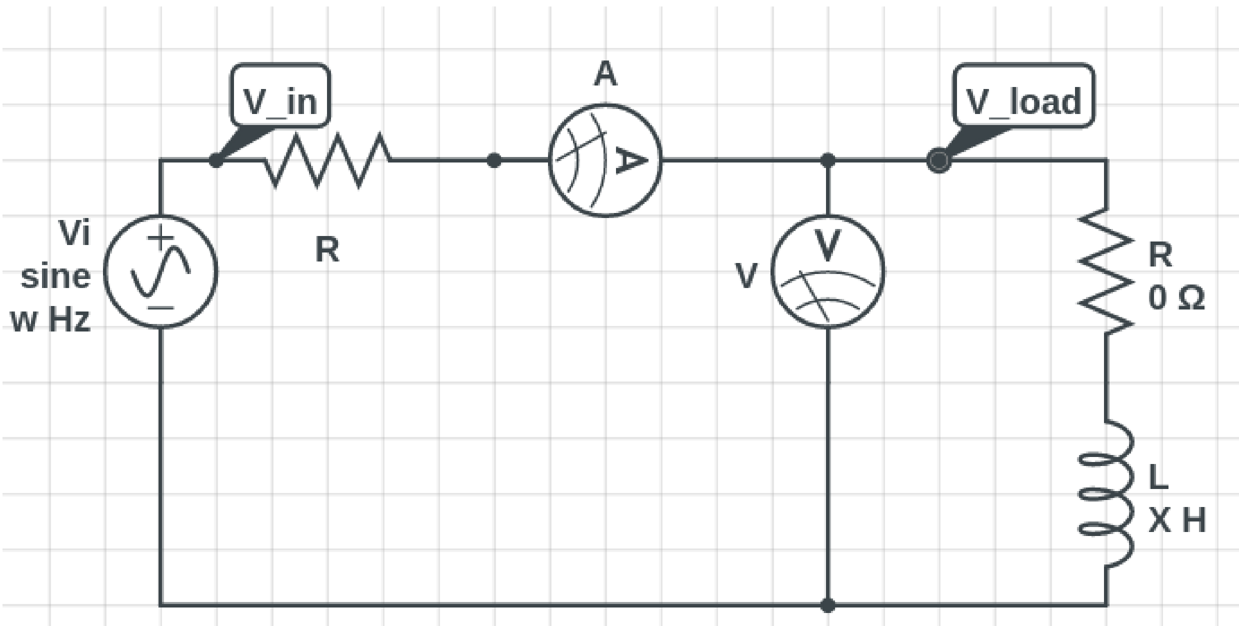


Figure 8: Proposed circuit for Capacitance measurement

Now let us derive the expression for capacitance;

$$V_c(t) = V_m cos(\omega t + \phi) \ \Rightarrow in\, phasors\, V_m \angle\phi$$

$$i_c(t) = CDV_c(t) = CV_m(-\omega)sin(\omega t + \phi)$$

$$= -C\omega V_m cos(\omega t + \phi - 90)$$

$$= -C\omega V_m \angle\phi - 90\circ$$

$$V_{in} = V_i \angle -90\circ$$

$$Z = \frac{V_c}{I_c} = \frac{V_{in}\angle\phi}{-C\omega V_m \angle\phi - 90\circ} = \frac{\angle 90\circ}{-C\omega} = \frac{J}{-C\omega} = \frac{1}{j\omega C}$$

$$|Z| = \frac{V}{A} = \frac{1}{C\omega} \Rightarrow C = \frac{A}{V\omega}$$

# 3 Step 3

To determine a method to measure the unknown inductance value L, the circuit given in Figure 9 needed to be constructed.

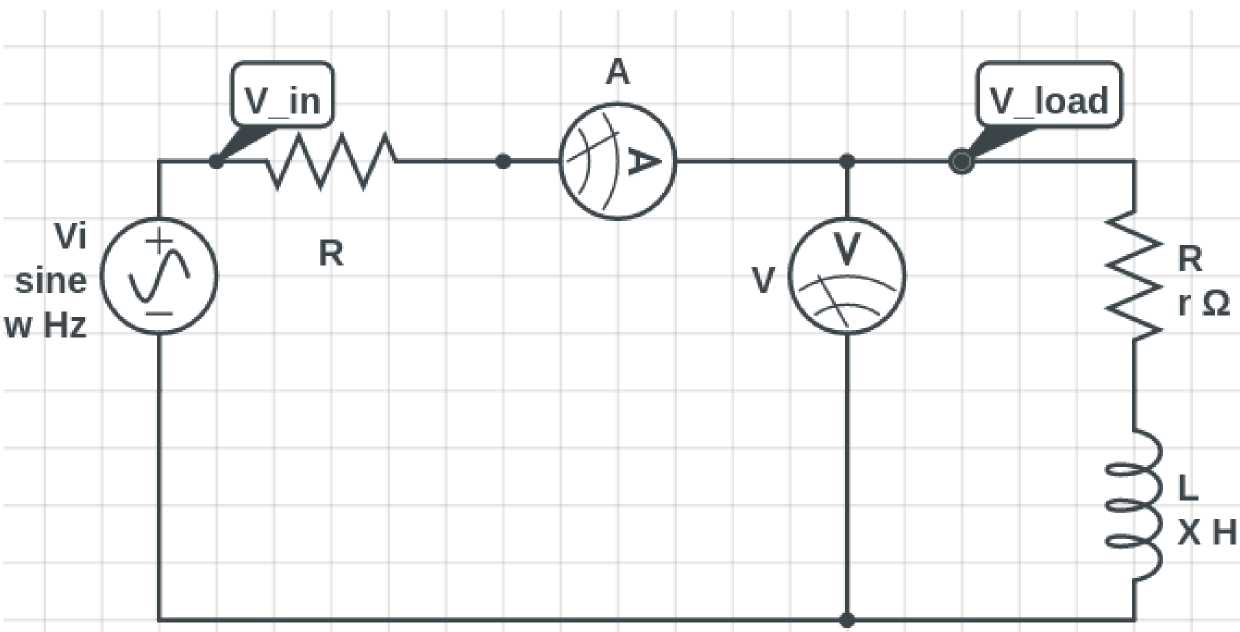


Figure 9: Proposed circuit for inductance measurement

Now let us derive the expression for inductance;

$$V_{in}(t) = V_i cos(\omega t + -90) \;\Rightarrow in\, phasors\, V_i n \underline{/-90}$$

$$Z_L = r + j\omega L \Rightarrow |Z_L| = \sqrt{r^2 + \omega^2 L^2} = \frac{V_{rms}}{I_{rms}}$$

$$I^2\omega^2 L^2 = V^2 - I^2 r^2$$

$$So;\; L = \frac{\sqrt{V_{rms}^2 - I_{rms}^2 r^2}}{I_{rms}\omega}$$

# 4 Step 4

In this step the circuit schematic given in Figure 10 is the reference.

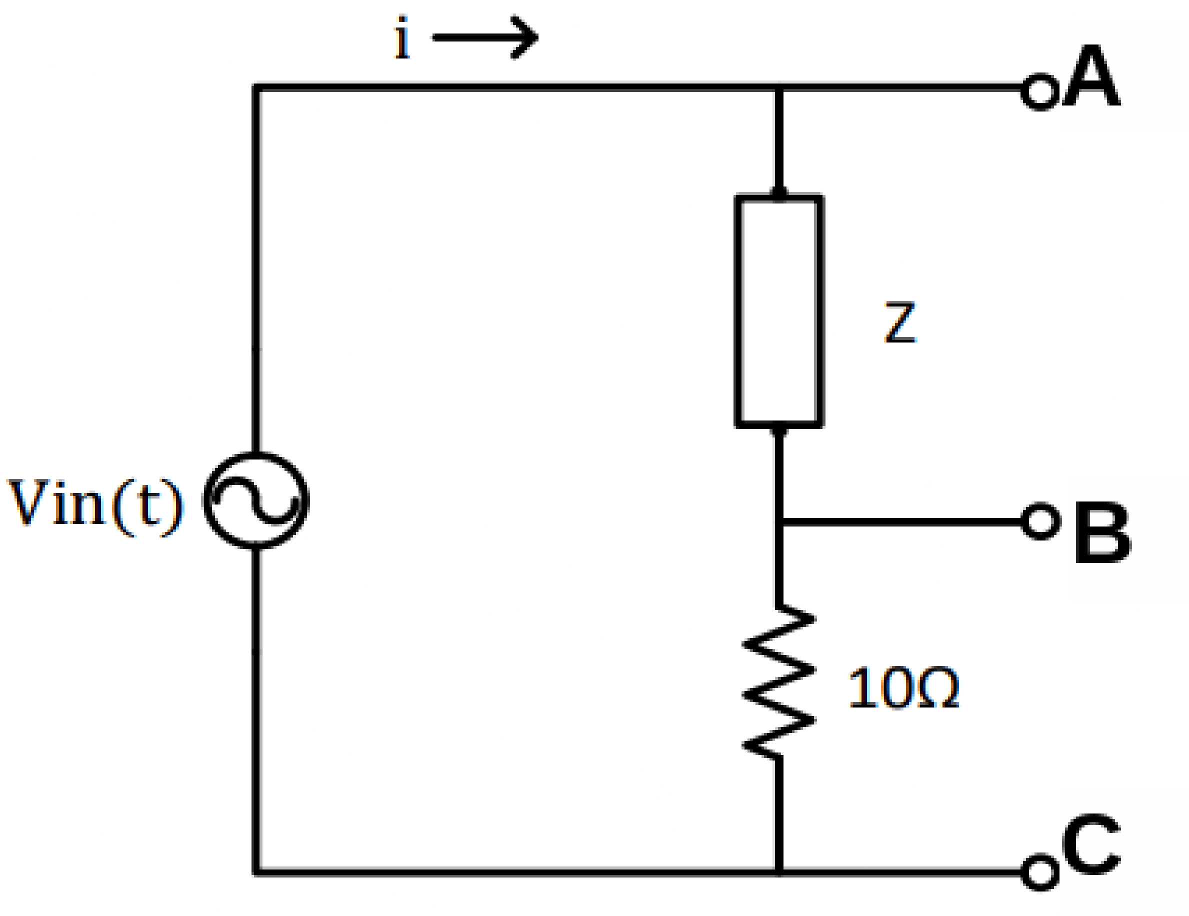


Figure 10: Circuit for impedance measurement

### 4.1 1st Method

In first method, the terminal A is denoted as channel 1 and terminal C is denoted as channel 2, terminal B is ground. Here, by inverting the channel 2 in XY mode one can obtain the impedance by dividing the slope by 10. The important thing here is in the signal supply is grounded this method would not work.

### 4.2 2nd Method

In the second method, the terminal A is denoted as channel 1 and terminal B is denoted as channel 2, terminal C is ground. Here one can measure the current by simply dividing the channel 2 by 10 and find the impedance by dividing the channel 1 by the current found. Since it is assumed 10ohm is much smaller than the impedance we could take channel 2 directly. This method can be applied in time mode and phase can be obtained from the measure mode of the DSO directly.

## 5 Conclusion

In this preliminary work document. Neccesssary simuloations concerning complex power are done and plotted. Then some of the measurement techniques for the capacitance , inductance and impedance are examined.

## Appendix A

The results of the simulations are fetched from LTSpice and plotted in MATLAB in order to make the plots more readable and convenient.